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Body dimensions in *Simoselaps* and *Vermicella* (Elapidae): a method for determining sex in natural populations

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Abstract – A total of 736 museum specimens of 11 different species of *Simoselaps* and *Vermicella* were examined in the laboratory. Snout–vent lengths and tail–vent lengths were measured and each specimen was sexed by dissection. Within species, females had larger snout–vent lengths than males, but for tail–vent lengths the converse was the case. The tail–body ratio for each specimen was determined by dividing the tail–vent length by the snout–vent length. Males and females of each species had a range of tail–body ratios which did not overlap. Tail–body ratios provide a simple and accurate method for sexing live fossorial snakes.

INTRODUCTION

Small fossorial snakes are among the most abundant snakes in parts of Australia but they are difficult to sample and have therefore attracted little study (Shine 1984). Fifteen species of small fossorial snake are found in Australia and eleven of these occur in Western Australia: *Simoselaps anomalus, S. approximans, S. bertholdi, S. bimaculatus, S. calonotos, S. fasciolatus, S. littoralis, S. minimus, S. roperi, S. semifasciatus* and *Vermicella multifasciata*. Four of them, *S. approximans, S. calonotos, S. littoralis* and *S. minimus*, are endemic to Western Australia (Storr *et al.* 1986).

The nomenclature used for these fossorial snakes varies among researchers. Some recognise three separate genera within the group (*Neelaps, Simoselaps* and *Vermicella*). However, in this paper the generic nomenclature of Cogger (1992) has been followed, with all the burrowing snakes in Western Australia being placed in the genera *Simoselaps* and *Vermicella*. Details of the geographical location and range of each species are described in various texts (Storr 1967; Storr *et. al* 1986; Cogger 1992).

Storr (1967), in his major revision of the burrowing snakes of Western Australia, provided data on the significance of body and tail dimensions in the group and pointed out the "...considerable correlation between the number of ventrals, total length and (inversely) relative length of tail."

The aim of this study is to use museum specimens of fossorial snakes to relate sex to external body dimensions in an attempt extend the work of Storr (1967, 1979) and provide a method of sexing snakes with reasonable confidence in the field.

MATERIALS AND METHODS

Eleven species and 736 specimens of fossorial snake occurring in Western Australia were examined in this study. All specimens are held at the Western Australian Museum. For each specimen the snout–vent length (SVL) and the tail–vent length (TVL) were measured to the nearest millimetre. Sex was determined by dissection and examination of the gonads. In the case of juveniles, or where the internal organs were missing or damaged, the specimens were recorded as unsexed. In a few cases sex was determined for specimens with fractured bodies or broken tails that were not used in further analysis. For *S. bertholdi* and *S. semifasciatus*, both numerically abundant in the collection, only a sample of the available specimens was examined and measured.

The tail–body ratio (TBR) was calculated by dividing the tail–vent length (TVL) by the snout–vent length (SVL) for each specimen.

In the case of two species, *S. fasciolatus* and *V. multifasciata*, specimens from each of the subspecies found in two distinct geographical locations were examined to determine if there was a difference between the geographical populations in the TBRs. *Simoselaps bertholdi* is found throughout a large area of southern and central Western Australia and specimens from different geographical regions within its range were examined to see if the TBR between sexes varied with geographical region. These regions were the southwest of the State, the Pilbara-Gascoyne area in the northwest and the deserts in the east.

The dimorphism in body dimensions between sexes in these fossorial snakes was evaluated by analysis of variance using the Statistix (1992) package.

RESULTS

The mean SVL of females exceeds that of males for all species except *S. anomalus*. The mean TVL is greater in males than females of each species (Table 1).

Tail–body ratio is strongly dimorphic with TBRs of males being higher than females (Table 2) and no overlap occuring between males and females in most species. An exception is observed in *S. fasciolatus fasciolatus* where the minimum male TBR is 0.1186 and the maximum female TBR is 0.1233. However, all other females in this species have a TBR <0.0918. Table 2 also shows the mean and range of tail–body ratios recorded for males and females in the subspecies of *S. fasciolatus* and *V. multifasciata*. The TBRs for the different sexes in the two subspecies *V. multifasciata multifasciata* and *V. multifasciata snelli* are different, with the ranges for the sexes in the two subspecies overlapping. There were insufficient specimens of *S. fasciolatus fasciatus* to allow comparison with the nominate subspecies *S. fasciolatus fasciolatus*.

The juvenile and unsexed *Simoselaps* and *Vermicella* specimens in this study were assigned to males and females on the basis of their tail–body ratios and the sex ratio obtained was similar to that of the sexed population.

There is no overlap in TBRs between males and females in *S. bertholdi* from different geographical regions, although there is some variation in the mean TBRs for the two sexes in the different regions. The TBR of southwest males is significantly lower on average than those in the northwest (Mann-Whitney U, p = 0.0035) and east (p = 0.0012), while females are not significantly different between areas.

DISCUSSION

In snakes it is common for females to exceed males in average size (Fitch, 1981; King 1989). The fossorial snakes investigated in this study follow this trend with females having greater mean SVLs than males and results are similar to those obtained by Shine (1984) in his study of fossorial snakes in Australia. However, *S. anomalus* provides an

Table 1 The mean snout–vent lengths and tail–vent lengths for male and female *Simoselaps* and *Vermicella* together with standard deviation, range and sample size. Significant differences between the sexes at P<0.01 are indicated by a single asterisk (*) and at P<0.001 by a double asterisk (**).

			Snout-vent length (cm)				Tail–vent length (cm)			
Species	Total	Sex	No	Mean	SD	Range	No	Mean	SD	Range
S. anomalus	27	M	18	15.2	1.6	11.5 – 17.7	18	2.2**	.3	1.6 – 2.5
		F	5	14.1	3.3	10.5 – 19.1	5	1.5**	.3	1.1 – 1.9
S. approximans	31	M	14	27.0	3.4	21.0 – 32.5	14	2.8**	.4	2.2 – 3.4
		F	10	27.8	4.1	20.5 – 35.5	10	2.2**	.2	1.8 – 2.6
S. bertholdi	213	M	87	16.9**	2.2	10.0 – 21.8	86	2.3**	.4	1.3 – 3.0
		F	80	19.7**	3.7	10.0 – 29.0	81	1.8**	.4	0.9 – 3.0
S. bimaculatus	65	M	27	24.9**	3.8	19.0 – 30.5	27	2.6**	.4	2.0 – 3.2
		F	29	29.8**	5.6	20.5 – 39.0	28	2.1**	.3	1.4 – 2.7
S. calonotos	81	M	37	19.3**	1.9	13.8 – 22.3	36	3.2**	.4	2.3 – 4.0
		F	32	21.7**	2.3	15.2 – 25.2	32	2.8**	.3	2.0 – 3.3
S. littoralis	84	M	29	16.0**	2.0	11.8 – 20.5	29	2.3	.3	1.7 – 2.9
		F	40	20.9**	5.3	12.3 – 35.8	40	2.1	.6	1.1 – 3.1
S. minimus	3	M	2	17.6	2.3	16.0 – 19.2	2	2.4	.4	2.1 – 2.7
		F	1	20.5		20.5 – 20.5	1	2.1		2.1 – 2.1
S. roperi	12	M	9	26.2	3.4	21.8 – 32.5	9	2.6*	.3	2.1 – 3.0
		F	2	27.6	3.6	24.9 – 30.0	2	1.8*	.6	1.4 – 2.2
S. semifasciatus	154	M	65	23.0**	3.4	13.8 – 30.0	65	2.6**	.4	1.5 – 3.7
		F	64	26.0**	4.1	15.0 – 34.2	63	2.0**	.4	1.0 – 3.0
S. fasciolatus fasciatus	4	M	2	27.5	0.7	27.0 – 28.0	2	3.7	.1	3.6 – 3.7
		F								
S. fasciolatus fasciolatus	40	M	18	25.6	4.9	13.4 – 31.2	18	3.3**	.6	1.7 – 3.9
		F	17	27.0	7.1	15.0 – 35.0	17	2.3**	.8	1.1 – 3.7
V. multifasciata multifasciata	9	M	2	33.3	5.3	29.5 – 37.0	2	2.4	.2	2.2 – 2.5
		F	6	41.5	10.2	24.6 – 51.3	6	1.9	.5	1.0 – 2.7
V. multifasciata snelli	13	M	4	34.0	2.9	31.1 – 38.0	4	1.8	.2	1.6 – 2.0
		F	8	36.4	9.3	21.2 – 48.5	8	1.5	.4	0.9 – 2.0

Table 2 The mean tail–body ratios (TBR) for males and females of *Simoselaps* and *Vermicella* together with standard deviation, range and sample size.

Species	Sex	No	Mean TBR	SD X 10^{-3}	Range	Mid-Point
	M	18	.1461	7.32	.1317 – .1612	.1241
S. anomalus	F	5	.1048	6.87	.0994 – .1164	
	M	14	.1039	6.16	.0945 – .1133	.0945
S. approximans	F	10	.0814	8.16	.0676 – .0945	
	M	86	.1341	9.48	.1127 – .1525	.1122
S. bertholdi	F	80	.0923	7.96	.0777 – .1116	
	M	27	.1031	7.04	.0915 – .1157	.0858
S. bimaculatus	F	28	.0707	5.06	.0589 – .0800	
	M	36	.1642	9.28	.1428 – .1818	.1397
S. calonotos	F	32	.1269	7.48	.1116 – .1366	
	M	29	.1420	8.50	.1277 – .1586	.1222
S. littoralis	F	40	.1028	8.38	.0865 – .1166	
	M	2	.1359	6.63	.1312 – .1406	
S. minimus	F	1	.1024			
	M	9	.0994	6.06	.0861 – .1044	.0814
S. roperi	F	2	.0647	12.1	.0562 – .0766	
	M	64	.1141	8.19	.0971 – .1347	.0929
S. semifasciatus	F	63	.0772	6.24	.0648 – .0888	
	M	2	.1328	5.99	.1285 – .1370	
S. fasciolatus fasciatus	F					
	M	18	.1284	5.79	.1186 – .1400	.1052
S. fasciolatus fasciolatus	F	17	.0852	12.5	.0611 – .0918 (.1233)	
	M	2	.0710	4.96	.0675 – .0745	.0615
V. multifasciata multifasciata	F	6	.0454	7.98	.0350 – .0555	
	M	4	.0528	2.08	.0514 – .0558	.0492
V. multifasciata snelli	F	8	.0403	4.30	.0328 – .0469	

exception that is probably due to the small sample size of females which contains a relatively high proportion of non-adult individuals. Conversely, the mean TVL was found to be larger in males than females in all species studied, which agrees with the findings of King (1989).

In a number of species the difference between males and females is highly significant for both SVL and TVL (Table 1). This occurs particularly in those species where the data set is relatively large. However, measurements of SVL and TVL do not allow determination of sex in themselves, rather, the two measurements taken as a ratio provide a useful tool for determining sex in these snakes.

The results of the study indicate that each species of *Simoselaps* and *Vermicella* in Western Australia has a tail–body ratio that does not overlap between sexes (Table 1) and adds further support to Storr's (1967) finding. One large female *S. fasciolatus fasciolatus*, with an exceptionally long tail, is responsible for the sole instance where overlap occurs in the male and female tail–body ratio ranges (Table 2).

The degree of confidence in determining the sex of specimens is greatly reduced where the data set is small, e.g., *S. minimus*, and tail–body ratios that fall within this zone of separation may prove difficult to assign to sex. Consequently, in Table 2 the mid point of the zone of separation for each species is presented as a value above and below which the sex for each individual can be assigned.

Significant variation in tail–body ratios is present between the same sexes of the two subspecies of *Vermicella multifasciata*. However, in the study there were insufficient specimens of *S. fasciolatus fasciatus* to make a useful comparison of the TBRs with the subspecies *S. fasciolatus fasciolatus*.

Storr (1967) found the absolute size of *S. bertholdi* specimens increases from the southwest to the north and east and that the relative length of their tails similarly increases. No overlap is found in the male and female TBRs of *S. bertholdi* from three different geographical regions even though the mean TBRs for male specimens from the southwest are significantly lower than the other two regions.

CONCLUSION

The greater Perth Metropolitan region of Western Australia has a rich and abundant reptile fauna comprising over 70 species. Since European settlement this fauna has been modified by development in the form of agriculture and urbanisation with the result that most species now

Table 3 The mean snout–vent length, tail–vent length and tail–body ratio including the standard deviation and range for males and females of *Simoselaps bertholdi* from three different geographical locations within Western Australia.

S. bertholdi Geographical location in W.A.	Sex	Snout–vent length (cm) No	Mean	SD	Range	Tail–vent length (cm) No	Mean	SD	Range	Tail–body ratio No	Mean	SD X 10^{-3}	Range
Southwest	M	56	16.4	2.0	10.0 – 19.5	55	2.2	.3	1.3 – 2.7	55	.1311	9.15	.1127 – .1515
	F	51	19.0	3.2	10.0 – 25.8	52	1.7	.3	0.9 – 2.3	51	.0909	6.58	.0794 – .1029
Northwest	M	14	17.3	2.1	12.2 – 20.3	14	2.4	.3	1.7 – 2.8	14	.1397	8.55	.1280 – .1524
	F	15	19.5	3.7	14.2 – 26.2	15	1.9	.4	1.4 – 2.4	15	.0949	8.61	.0777 – .1116
East	M	17	18.5	1.9	14.7 – 21.8	17	2.6	.3	1.9 – 3.0	17	.1391	7.06	.1279 – .1525
	F	14	22.5	4.1	16.3 – 29.0	14	2.1	.4	1.5 – 3.0	14	.0948	6.11	.0827 – .1060

persist in populations that are isolated on fragments of natural vegetation (How and Dell 1994). Particularly numerous in the near-coastal dune systems are fossorial skinks, legless lizards and snakes (How and Dell 1993). Our study of vertebrate fauna on remnant bushlands in the Perth region has verified that fossorial snakes can be locally abundant and may persist in remnant bushlands for many decades after isolation. Over 270 individuals of five species have been measured and released, with five species sympatric in some habitats. The method of sex determination described in this paper will help in future studies of population dynamics and should also be a useful tool for other field biologists working with these species.

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